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THE ALBERTA NEW OIL ROYALTY FORMULA:
74-04-01 TO 82-12-31
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Preface

This paper deals with the intricacies of calculating the royalty on new oil produced in Alberta. It has been prepared by Alan Webster, a Senior Economist on the staff of the Canadian Energy Research Institute, who developed a special interest in the topic. While the discussion may appear quite technical to some readers and overly simplistic to others, the goal was to provide as much information respecting the new oil royalty formula as simply as possible to those who do not have the background or time to work through the formulas and calculations. To facilitate the achievement of this goal, liberties have been taken with mathematical conventions, when necessary. In addition, metric standards are not adhered to for presentation of the results. Hopefully, this paper will serve as a useful summary and analysis for persons interested in the recent history of the Alberta new oil royalty formula and to those who must understand the mechanics underlying the royalty calculation in order to fully appreciate the consequences of changes to the formula on producer cash flows.

Any comments or suggestions relating to the analysis presented here, should be forwarded to Alan Webster or the Executive Director, Canadian Energy Research Institute.

EXECUTIVE SUMMARY

The Alberta Crown oil royalty has been calculated from 74-04-01 to 82-12-31 by the following formula:

$$R = S(1 + k(A-B)/A).$$

R is the provincial royalty in m^3(bbl), S is a royalty factor measured in m^3(bbl) and is a function of production levels. The calculation of S has been modified only once since 74-04-01. The term 1 + k(A-B)/A, referred to as "the multiplier," has changed numerous times, reflecting the values of the constant terms k, A, B which are set at the discretion of the provincial government. The above formula differentiates among types of oil--old, new and NORP--solely on the basis of the values chosen for the constant terms, k and A. The calculation of S is well documented and publicly available, but the methodology for determining the terms k, A, and B is not.

This paper discusses three aspects of the Alberta new oil Crown royalty formula. First, the historical values of the new oil royalty parameters are given as are the interactions between these parameters, and possible anomalies in the published parameters are identified. Second, a set of reasonable limiting values for the terms k and 1 + k(A-B)/A is given. Finally, an estimate of the bias associated with calculating the royalty formula in constant dollars as opposed to nominal dollars, with the results expressed in present value terms is presented.

Although this paper discusses "new" oil (including NORP oil), the results can easily be extended to "old" oil. The emphasis on new oil reflects its increasing contribution to total Alberta oil production.

The overall conclusions of the present analysis are:

1. It would be helpful if the methodology for the determination of the parameters A, B and k could be clarified or, alternatively, the royalty formula could be simplified to be a function solely of production. The current level of complexity in the formula is not warranted by the degree of fine tuning that is obtainable as a result of this complexity.

2. There appear to be a number of anomalies in the values of the constant terms, and hence in the values of the corresponding multiplier terms from 81-09-01 to the present. Utilization of some limiting value, say 1.615385 for the multiplier, would simplify the procedure significantly.

3. The bias resulting from calculating royalties payable in constant dollars as opposed to nominal dollars in present value terms is small. This reflects the current values of the royalty formula parameters. Should crude oil prices increase, then the bias will become even smaller. Currently, with prices decreasing, the bias will increase, but prices will have to decrease considerably before the bias will become significant.

SECTION 1

INTRODUCTION

The Alberta Crown oil royalty formula consists of a simple algebraic relationship between royalty barrels payable to the provincial government, producers' production levels and average prices. There does however appear to be some confusion about the formula which reflects a lack of information with respect to the definition, determination and interpretation of the constant terms in the formula.

This paper firstly identifies the historical values of the constant terms utilized in the royalty formula, interactions between these constants, and possible anomalies in the published values for the constants. Secondly, a set of probable limiting values for the royalty formula for a range of values for the constant terms are given. Finally, potential bias resulting from performing the royalty calculation in constant rather than in nominal dollar terms (and then discounting to the present) is addressed.

The basis of the current royalty regulations was established in 1974. From 1974-04-07 to the present, 82-12-31, Alberta oil has been differentiated into classes of oil based on the time of discovery and/or the method of production. The royalty formula has also been differentiated to account for these classes of oil. This is achieved by varying the values of the constant terms in the formula. The present discussion of the royalty formula, is confined to the formula applicable to the class of oil referred to as new oil.

The historical definitions for the classes of oil are presented in the following subsection. To capture the essence of the definitions, as much material as possible has been extracted verbatim from original documents. In most cases these definitions are self-explanatory.

The last subsection gives the historical definitions for the royalty formula for new oil.

A. Oil Class Definitions

Initially, in 74-04-01, Alberta oil production was segregated into two classes: old and new oil. New oil was defined to be:

1. crude oil obtained from a new oil well, which is a well for which the well license under the Oil and Gas Conservation Act was issued on or after 74-04-01 and that, in the opinion of the Minister, obtains

   i. crude oil from a pool initially discovered on or after 74-04-01, or

   ii. crude oil from a pool initially discovered before 74-04-01 and that:

   (A) is located outside the area that has been or may be designated for the pool under the Oil and Gas Conservation Act on the basis of wells drilled into the pool before April 1, 1974, and

   (B) is producing crude oil from a production spacing unit, block or project (as defined in the Oil and Gas Conservation Act) that is located wholly outside the area referred to in paragraph (A);

2. crude oil obtained as a result of an enhanced recovery scheme conducted under an order or approval made pursuant to section 25 or 26, respectively of the Oil and Gas Conservation Act and dated on or after January 1, 1974, that portion of the crude oil so obtained which, in the opinion of the Minister, is attributable to the increase in reserves recognized by the Energy Resources Conservation Board as resulting from an enhanced recovery mechanism other than an enhanced recovery mechanism authorized by any previous order under either of those sections dated before January 1, 1974 and relating to the same pool or part thereof;

3. with the approval of the Minister, crude oil produced from an oil pool 3 years or more

> after production from that pool has ceased according to the records of the Energy Resources Conservation Board.[1]

Old oil was defined to be crude oil other than new oil. These definitions were effective from 74-04-01 to 81-09-01, a period of nearly seven and one-half years. It should be noted that part 2 of the new oil definition included production by secondary recovery methods if such production commenced after 74-04-01.

The 81-09-01 "Memorandum of Agreement Between the Government of Canada and the Government of Alberta Relating to Energy Pricing and Taxation" identified a class of oil which qualified for a New Oil Reference Price (NORP). Oil that qualified for NORP, as of 82-01-01, was defined to be:

- oil from pools initially discovered after December 31, 1980;
- "incremental oil", as determined by the fixed ratio method, recovered from pools or portions of pools subject to enhanced recovery schemes (other than waterflood schemes) commencing operation after December 31, 1980; and
- crude bitumen obtained from experimental and non-integrated oil sands projects commencing operation after December 31, 1980.[2]

The interesting exclusion from this definition is that of oil produced by waterflood schemes. This constitutes a major departure from the provincial definition for enhanced recovery, as embodied in the Oil and Gas Conservation Act, but follows the definition established by the Government of Canada in The National Energy Program: 1980.[3]

The main distinction to be noted at this point is that the Government of Canada distinguished between NORP oil and old oil for pricing purposes. Note that old oil, according to federal regulations, is all non-NORP oil. In Alberta however, royalty calculations are based on NORP oil, new oil and old oil. The NORP and new oil categories were treated identically for royalty calculations. The definition of NORP oil is the same for the two levels of government, while the

federal government definition of old oil includes the Province of Alberta's new and old oil classes.

Alberta Energy and Natural Resources clarified (in ENR I.L. 81-8, dated 81-09-24) the Government of Canada's NORP definition as follows:

1. Oil from pools initially discovered after December 31, 1980 will include all conventional heavy, medium or light gravity crude oil produced from new oil pools or extensions of existing oil pools discovered on or after January 1, 1981. Additionally, "conventional new oil" shall include, with the approval of the Minister, crude oil produced from an oil pool three years or more after production from that pool has ceased according to the records of the Energy Resources Conservation Board, provided that such oil commences production on or after January 1, 1981. The procedures to be used in defining these kinds of "conventional new oil" are analogous to those set out in Alberta Mines and Minerals Information Letter 74-12 for purposes of distinguishing between old oil and new oil under the Petroleum Royalty Regulations, A.R. 93/73 as amended.

2. Incremental oil will include all conventional heavy, medium or light gravity crude oil produced from a qualifying enhanced recovery scheme--other than waterflood or equivalent schemes--approved by the Energy Resources Conservation Board and commencing operation on or after January 1, 1981. In general, the procedures to be used in defining "qualifying enhanced recovery scheme" and the volume of "incremental oil" attributed to such a scheme are those set out in Alberta Mines and Minerals Information Letter 74-12.[4]

An "equivalent scheme" is defined (in ENR I.L. 81-10, dated 81-11-23):

> to be equivalent to a waterflood if in the opinion of the Department it does not have a substantially greater recovery efficiency than a comparable waterflood scheme in the same field, pool, or part thereof.[5]

This definition of an equivalent scheme presumably encompasses gas reinjection for pressure maintenance schemes. By these definitions only waterflood schemes commencing in or after 81-01-01 will result in an increase in qualifying volumes for the Alberta Government's new oil class.

Additional clarification of hydrocarbon production qualifying for NORP pricing was provided in ENR I.L. 82-3 and I.L. 82-4 both dated 82-03-23. The former dealt with conventional heavy oil and crude bitumen while the latter covered pentanes plus.[6] The relevant portion of I.L. 82-3 is reproduced below:

Categories of Conventional Heavy Oil and Crude Bitumen Qualifying for New Oil Reference Price (NORP)

CATEGORIES

Further to Information Letters 81-8 and 81-10, the Department advises that the following categories of conventional crude oil and crude bitumen may qualify for the New Oil Reference Price, adjusted for quality and transportation factors, effective on the dates as shown below:

A. Effective January 1, 1982

1. Crude bitumen obtained from experimental non-integrated oil sands schemes commencing operations on or after January 1, 1981.

The Department shall interpret this category to include all such schemes approved by the ERCB which commenced injection of fluids on or after January 1, 1981 pursuant to ERCB approval. Approved schemes located on Crown lands must be subject to the Experimental Oil Sands Royalty Regulation (A.R. 287/77).

2. Crude oil obtained from experimental heavy oil schemes commencing operations on or after January 1, 1981.

The Department shall interpret this category to include all such heavy oil schemes approved by the ERCB which commenced injection of fluids on or after January 1, 1981 pursuant to ERCB approval. Approved schemes

located on Crown lands must be subject to the Experimental Project Petroleum Royalty Regulation (A.R. 36/79).

B. Effective April 1, 1982

3. Crude bitumen obtained from experimental non-integrated oil sands schemes commencing operations before January 1, 1981.

The Department shall interpret this category to include all such schemes approved by the ERCB which commenced injection of fluids before January 1, 1981 pursuant to ERCB approval, excepting the scheme subject to ERCB Approval #2943. Approved schemes located on Crown lands must be subject to the Experimental Oil Sands Royalty Regulation (A.R. 187/77).

4. Crude oil obtained from experimental heavy oil schemes commencing operations before January 1, 1981.

The Department shall interpret this category to include all such schemes approved by the ERCB which commenced injection of fluids before January 1, 1981 pursuant to ERCB approval. Approved schemes located on Crown lands must be subject to the Experimental Project Petroleum Royalty Regulation (A.R. 36/79).

5. Heavy oil with a density of 950 kg/m^3 or greater (approximately 17.5° API), produced from a well well which:

(a) is within a pre-NORP oil entity,

(b) has a finished drilling date occurring on or after January 1, 1981,

(c) is completed in a pool for which the spacing units established prior to January 1, 1981 comprise 16 hectares (40 acres) or greater, and

(d) is in a spacing unit which was undrilled prior to January 1, 1981.

6. Heavy oil with a density of 950 kg/m^3 or greater (approximately 17.5° API), produced from a well in a spacing unit established on or after January 1, 1981, providing that:

(a) in the opinion of the ERCB the oil would have been unrecoverable if the well had not been drilled,

(b) the well is within a pre-NORP oil entity,

(c) the well had a finished drilling date occurring on or after January 1, 1981,

(d) the well is completed in a pool for which the spacing unit established on or after January 1, 1981 comprises 16 hectares (40 acres) or greater, and

(e) the well produces from a spacing unit which was undrilled prior to January 1, 1981.[7]

The release of The National Energy Program: Update 1982 on 82-05-31 by the Government of Canada included additional categories of hydrocarbon production in the NORP classification. It was stated that the New Oil Reference Price would be extended, effective 83-01-01, to include:

1. existing tertiary recovery projects which pay royalties no higher than those applicable to new oil;

2. all experimental projects which pay a royalty no greater than 5 per cent of gross revenue;

3. oil wells that have been suspended for a period of at least three years, provided the production from these wells qualifies for new oil royalties.[8]

The Province of Alberta clarified the above definitions on 82-07-20 in ENR I.L. 82-17. The relevant portion is reproduced below:

The Department advises that the following categories of conventional crude oil and crude bitumen shall be eligible to qualify for the New Oil Reference Pricing (NORP) program effective Reference Pricing (NORP) program effective January 1, 1983:

C. Conventional Crude Oil

1. Oil obtained from an experimental scheme which has been approved by the Energy Resources Conservation Board (ERCB). Approved schemes located on Crown lands must be subject to the Experimental Project Petroleum Royalty Regulation (A.R. 36/79).

2. Incremental oil produced from an enhanced recovery scheme, other than a waterflood or equivalent scheme as approved by the ERCB, where the ERCB's enhanced recovery recognition date for the scheme predates January 1, 1981.

3. Oil produced from a Crown or freehold well in a drilling spacing unit, provided that:

   (a) at least one well produced crude oil in the drilling spacing unit, and

   (b) production of crude oil from the drilling spacing unit has ceased for a continuous period of three years, and

   (c) production of crude oil from the drilling spacing unit resumed on or after January 1, 1981, from a reactivated or replacement well, and

   (d) the Minister is of the opinion that the reactivation or replacement of the well in the drilling spacing unit has enabled, or will enable, the recovery of crude oil that would not have been recoverable if the well had not been so reactivated or replaced.

D. Crude Bitumen

1. Crude bitumen produced from experimental scheme subject to ERCB approval No. 2943.[9]

From the preceding classification[10] of oil, the NORP component and the new oil component, as defined by the Alberta Government, qualify for application of Alberta's royalty formula for new oil.[11] Basically this includes most oil production which commenced after 74-04-01, with a number of special cases and exceptions.

B. New Oil Royalty Formulas

There has been little change in Alberta's royalty formula since 74-04-01. It is essentially the same for old, new and NORP oil and is defined to be:[12]

$$R = S(1 + k(A-B)/A)$$

where: R is the monthly provincial Crown oil royalty in m^3(bbl)

S is a monthly provincial Crown oil royalty factor in m^3(bbl)

A is the par price in \$/m^3(\$/bbl)

B is the select price in \$/m^3(\$/bbl)

k is a royalty factor for the month.

The terms S, A, B, and k are set by the province. S is defined by a documented formula which is provided in the next section. The terms A, B, and k are set by the provincial government, at its discretion. The term A, the par price, is essentially an average field price and the term B, the select price, is a minimum or base price.

The above formula was effective for all classes of oil from 74-04-01 to 82-01-01. In January of 1982 a new royalty formula applicable only to NORP oil was devised. Two constants were changed, such that the formula became:

$$R = S(1 + y(X-B)/X)$$

where y is the NORP royalty factor for the month and X is the adjusted NORP base price for the month. All other terms remained as defined previously.[13] The royalty formula for old and new oil was unchanged.

A conversion from Imperial to metric units was to occur on 79-01-01 but the mandatory conversion date was deferred until 79-07-01.[14] The actual changes to the relevant regulations to bring the metric conversion into force are codified in Alberta Regulation 249/79.[15] The only significant conversion was from barrels to cubic meters (1 bbl = .1589$1m^3$).

Utilizing the preceding time-differentiated definitions of oil qualifying for application of the new oil royalty formula and the definitions of the new oil royalty formula, the paper proceeds as follows: Section 2 discusses the term S, which is well documented elsewhere; Section 3 discusses the terms A(or X), B, k(or y) and 1 + k(A-B)/A,

whose values are well documented elsewhere but not the methodology for their determination; Section 4 presents the nominal versus constant dollar royalty calculation and Section 5 contains a summary and conclusions.

Footnotes

[1]These definitions have been extracted from Petroleum Royalty Regulations, Alberta Regulation 93/74 as amended, up to and including AR 462/82, in Alberta, Energy Statutes and Regulations, pp. 291-292.

In addition, sections 24, 25 and 26 of the Oil and Gas Conservation Act, Revised Statutes of Alberta 1980, Chapter O-5, as amended to 82-06-15, are reproduced below. Sections 25 and 26 relate, respectively, to sections 37 and 38 of the Oil and Gas Conservation Act, Revised Statutes of Alberta 1970, Chapter 267. Subsequent reference to sections from the Oil and Gas Conservation Act correspond to the 1980 Statutes, unless otherwise stated.

Conservation Projects

Disposal of water

24 The Board may, by order,

(a) control and regulate the production of oil, gas and water by restriction, proration or prohibition, or

(b) require the disposal into an underground formation or otherwise, in accordance with any terms and conditions that the Board may prescribe, of any water produced.

RSA 1980 cO-5 s24

Prevention of waste

25 In order to prevent waste, the Board, with the approval of the Lieutenant Governor in Council, may

(a) require enhanced recovery operations in any pool or portion of a pool, and for or incidental to that purpose require the introduction or injection into the pool or portion of a pool of gas, air, water or other substance or a form of energy, and

(b) require that any gas, on its production, be gathered, processed if necessary, and the gas or products from it marketed or injected into an underground reservoir for storage or for any other purpose.

RSA 1980 cO-5 s25

Approval of scheme

26(1) No scheme for

(a) enhanced recovery in any field or pool,

(b) the processing or underground storage of gas,

(c) the gathering, storage and disposal of water produced in conjunction with oil or gas,

(d) the storage or disposal of any fluid or other substance to an underground formation through a well,

(e) the concurrent production of an oil accumulation and its associated gas cap, or

(f) the production of gas occurring within or immediately adjoining oil sands,

shall be proceeded with unless the Board, by order, has approved the scheme on any terms and conditions that the Board prescribes.

(2) Prior to the Board approving a scheme under subsection (1)(b) or (d), it shall refer the application to the Minister of the Environment for his approval with respect to the application as it affects matters of the environment.

(3) The Minister of the Environment may give his approval with or without conditions, but when conditions are imposed, the Board shall, if it approves the scheme, make its order subject to the same conditions imposed by the Minister of the Environment when he gave his approval.

(3.1) Notwithstanding subsection (2), the Minister of the Environment may direct that

(a) an application, or

(b) a type of application

for any approval of a scheme or an amendment of an approval specified by him be not referred to him.

(3.2) The Minister of the Environment may authorize an employee of his department to exercise the powers conferred on him by this section.

(4) Notwithstanding subsection (3), the Board is not required to impose the conditions specified by the Minister of the Environment when the Lieutenant Governor in Council directs that the conditions are not to be imposed.

RSA 1980 cO-5 s26; 1982 c27 s5

The definition of "enhanced recovery" according to the Oil and Gas Conservation Act 1980, is:

"the increased recovery from a pool achieved by artificial means or by the application of energy extrinsic to the pool, which artificial means or application includes pressuring, cycling, pressure maintenance or injection to the pool of a substance or form of energy but does not include the injection in a well of a substance or form of energy for the sole purpose of

(i) aiding in the lifting of fluids in the well, or

(ii) stimulation of the reservoir at or near the well by mechanical, chemical, thermal or explosive means."

[2]See Memorandum of Agreement Between the Government of Canada and the Government of Alberta Relating to Energy Pricing and Taxation, p. 3.

[3]See The National Energy Program: 1980, p. 28 for a definition of enhanced oil recovery.

[4]See Alberta Energy and Natural Resources (ENR) Information Letter (I.L.) 81-8 dated 81-09-24.

[5]See Alberta ENR I.L. 81-10.

[6]See Alberta ENR I.L. 82-4, but note that pentanes-plus are not subject to the oil royalty formula.

[7]Taken from Alberta ENR I.L. 82-3. Pre-NORP oil entities, which are mentioned in this document, are identified in the ERCB publication, "Pre-NORP Oil Entities, as of 80-12-31." This publication identifies the geographic areas where Pre-NORP oil is produced.

The Alberta Regulation 287/77, "Experimental Oil Sands Royalty Regulation," referenced in I.L. 82-3 defines the oil production from an experimental oil sands project, that qualifies for the experimental oil sands royalty rate, which is set at 5 percent. Reference should also be made to section 31(6) of the Oil and Gas Conservation Act 1980.

Alberta Regulation 36/79 "Experimental Project Petroleum Royalty Regulation", defines oil production from a project designated as experimental that qualifies for the experimental project petroleum royalty rate which is set at 5 percent. Reference should also be made to section 26(1)(a) of the Oil and Gas Conservation Act 1980.

The scheme, subject to ERCB Approval #2943 which is referred to in ENR I.L. 82-3, is an Esso Resources Canada experimental oil sands project currently being undertaken on Sections 4, 5, 6, 7 and 8 of Township 65, Range 3, West of the 4th Meridian as defined in ERCB Approval No. 2943A which amends Approval No. 2943.

[8]See The National Energy Program: Update 1982, pp. 74-75.

[9]Taken from Alberta ENR I.L. 82-17. This reverses the exclusion of the Esso scheme that was excepted in the previous ENR I.L. 82-3. (See footnote 7 above.)

[10]The National Energy Program: Update 1982 contains a modification of the oil classification terminology. This terminology was utilized to facilitate the differentiated prices for oil type. Summary classifications are:

Province of Alberta	Government of Canada
Old oil	Conventional old oil price (COOP) oil
New oil*	Special old oil price (SOOP) oil
NORP oil*	New oil reference price (NORP) oil

*Qualifying oil classifications for new and/or NORP oil Alberta royalty formula calculations.

The SOOP classification is a temporary one, currently expected to be eliminated by 83-07-01. Under the Alberta/Ottawa energy pricng agreement, NORP oil (delivered in Montreal) was priced with pre-set increases through to 1986 but was constrained to not exceed 100 percent of the actual laid-down cost of international crude in Montreal after adjusting for quality differentials. (See pages 4, 5 and S5

of the energy pricing agreement for details). The reference oil for NORP is 38° API and 0.5 percent sulphur.

Old oil, adjusted for quality differentials and transportation costs, was to increase at pre-determined levels every six months. Its increases were constrained, such that the average field price of old oil would never exceed 75 percent of the laid-down cost of international oil in Montreal. Furthermore, the price of any particular quality of old oil was not to exceed 100 percent of the NORP oil price for a similar quality of crude.

This process was modified on 82-05-31 in the National Energy Program: Update 1982 (see page 74 for details). At that time it was announced that, effective 82-07-01, there would be a new class of old oil which would qualify for a special old oil price (SOOP). This oil classification was equivalent to the Alberta Government's new oil classification. SOOP oil would immediately receive 75 percent of the current international price, and continue to receive this level, $\$190.50/m^3$, until the remainder of the oil qualifying for the conventional old oil price (COOP) reaches this price level by continuing to be priced according to the Alberta/Ottawa energy pricing agreement. It is expected that COOP and SOOP will be equivalent by 83-07-01 (and possibly earlier based on expectations of performance in the international crude oil market), at which time these two oil classifications will be similarly treated for pricing purposes. For royalty calculations however, the Alberta government classifications will be maintained.

[11]In cases where production is comprised of more than one classification of oil, ENR I.L. 74-12, dated 74-10-02, sets out the methodology for ascertaining the respective shares for the old and new oil components. ENR I.L. 81-10 sets out the methodology for determining the shares of the NORP and pre-NORP oil components. It is interesting to note the definition of "incremental oil" in I.L. 81-10 (p. 2), dated 81-11-23:

> "Incremental Oil" means crude oil that is additional to that recoverable by a waterflood or equivalent scheme, as determined by the fixed ratio method, and is recovered from pools or portions of pools subject to enhanced recovery schemes (other than waterflood or equivalent schemes) commencing operation on or after January 1, 1981.

The key phrase is "as determined by the fixed ratio method" which occurred in the incremental oil definition in the Alberta/Ottawa energy pricing agreement but was not included

in the clarifying ENR I.L. 81-8 of 81-09-24. Presumably its subsequent inclusion was to ensure consistency between pricing and royalty mechanisms. Oil receiving NORP or new oil prices, even if based on a "determination by the fixed ratio method" should pay corresponding royalties at that time.

There are special deductions allowed for the calculation of royalties for enhanced recovery other than a waterflood or equivalent scheme, but these are not included in this paper. Reference for these should be made to Alberta Energy Statutes and Regulations, pp. 299-301 and to "Application Procedures: Petroleum Royalty Relief - E.O.R. Schemes." The actual royalty calculation is not affected, however, the eligible production for royalty payments is.

[12]See Schedule B of Petroleum Royalty Regulations, Alberta Regulation 93/74 as amended, in Alberta Energy Statutes and Regulations, p. 303.

[13]See ENR I.L. 82-2 and Schedule C of Petroleum Royalty Regulations 93/74 as amended, in Alberta Energy Statutes and Regulations, p. 304.

[14]See ENR I.L. 78-26 and additionally an ENR letter dated 79-01-25 to "Operators Producing Conventional Crude Oil" re: Conversion of the Petroleum Royalty Formula to S.I. (metric) Units for Royalty Calculation and Verification Purposes" which contains an example, in some detail, of the metric royalty calculation, including rules for rounding.

[15]See ENR I.L. 79-8.

SECTION 2

CALCULATION OF S

The methodology for the calculation of S in the royalty formula presented in the previous section is given in Schedule A (p. 302) and again in the Table in Schedule B (p. 303) of Alberta Energy and Natural Resources, Energy Statutes and Regulations.[1]

The formula for S is reproduced below:

$$S = P^2/1271.28, \qquad 0 \leq P < 190.7$$

$$= 28.6 + .25(P - 190.7), \qquad P \geq 190.7$$

where, S is a royalty factor in cubic meters

P is production in cubic meters.

All calculations are performed, with rounding, utilizing six decimal digit accuracy with the final value reported, with rounding, utilizing two decimal digit accuracy.

The only distinction between Schedule A and the Table in Schedule B is that the former identifies the right-hand side of the above equation as being "the Crown Royalty for the Month in Cubic Meters",[2] whereas in the latter the right side of the equation is identified simply as "S" and is defined as "the number of cubic meters determined in accordance with the Table in this Schedule".[3] No further explanation is given accounting for this occurrence.

The above formula for S was effective from 79-07-01 to the present.[4] As of 79-07-01 it was mandatory that all royalty calculations be performed in metric units. The original date set for the mandatory metric calculation was 79-01-01, but a six month extension to 79-07-01 was granted.[5]

The metric formula for S prior to 79-07-01 was:

$$S = (((P/19.07) + 5) \times P)/100, \quad 0 \leq P < 190.7$$

$$= 28.6 + .25(P - 190.7), \quad P \geq 190.7$$

This formula and an example of the royalty calculation were presented in an ENR letter dated 79-01-25 to "Operators Producing Conventional Crude Oil" re: "Conversion of the Petroleum Royalty Formula to S.I. (Metric) Units for Royalty Calculations and Verification Purposes".[6]

The Imperial unit equivalent of the above formula for S was:

$$S = (((P/120) + 5) \times P)/100, \quad 0 \leq P < 1200$$

$$= 180 + .25(P - 1200), \quad P \geq 1200$$

This earlier version of the formula for S, effective 74-01-01, is documented in ENR I.L. 74-4.[7]

The relationship between S and P, in metric units, is presented in Figures 2.1 and 2.2 and in Table 2.1, for both the current and old regulations.

It is readily seen from Figure 2.2 and Table 2.1 that the current regulation provides some royalty payment relief for low productivity wells (<190.7 m^3/mo), relative to the old regulation. Figure 2.2 emphasizes the relationship for production in the range zero to 190.7 m^3/mo. Table 2.1 provides the data that are utilized in Figures 2.1 and 2.2. In addition, Table 2.1 presents S expressed as a percentage of production. Obviously, S approaches 25 percent of P as P tends to infinity, which sets an effective upper limit for the ratio, S/P. Two other points of interest are for production levels of 190.7 m^3(1200 bbl) and 572.1 m^3. (3600 bbl) For these values of P, S as a percentage of P is 15 percent and 21.67 percent respectively.

This component of the royalty formula is simple, straightforward and introduces no ambiguities as to the intent or objective of the Province relative to the producer.

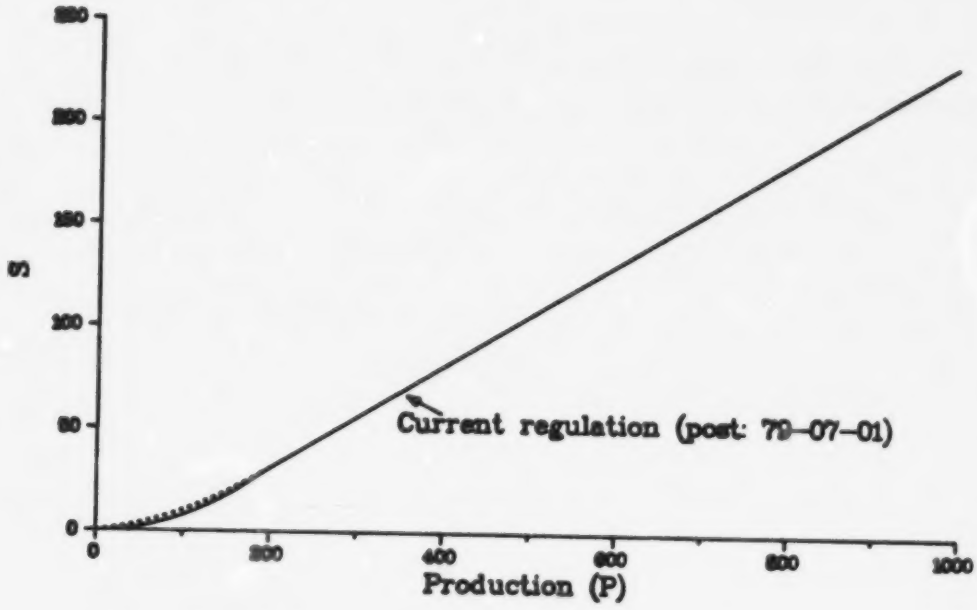

Figure 2.1: S versus P

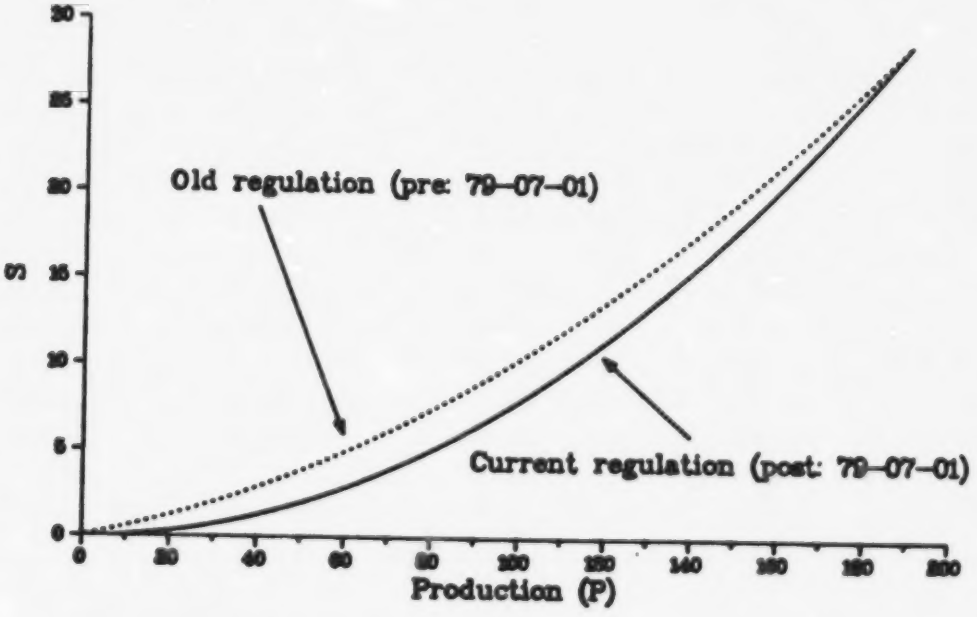

Figure 2.2: S versus P for P < 190.7 m^3

TABLE 2.1

RELATION BETWEEN S AND P

P	S			
	Current Regulation		Old Regulation	
m^3	m^3	%	m^3	%
0	0	0	0	0
10	.08	.79	.55	5.52
20	.31	1.57	1.21	6.05
30	.71	2.36	1.97	6.57
40	1.26	3.15	2.84	7.10
50	1.97	3.93	3.81	7.62
60	2.83	4.72	4.89	8.15
70	3.85	5.51	6.07	8.67
80	5.03	6.2	7.36	9.20
90	6.37	7.08	8.75	9.72
100	7.87	7.87	10.24	10.24
110	9.52	8.65	11.85	10.77
120	11.33	9.44	13.55	11.29
130	13.29	10.23	15.36	11.82
140	15.42	11.01	17.28	12.34
150	17.70	11.80	19.30	12.87
160	20.14	12.59	21.42	13.39
170	22.73	13.37	23.65	13.91
180	25.49	14.16	25.99	14.44
190	28.40	14.95	28.43	14.96
190.7	28.61	15.00	28.61	15.00
200	30.93	15.46	30.93	15.46
400	80.93	20.23	80.93	20.23
572.1	123.95	21.67	123.95	21.67
600	130.93	21.82	130.93	21.82
800	180.93	22.62	180.93	22.62
1000	230.93	23.09	230.93	23.09
10000	2480.93	24.81	2480.93	24.81

Footnotes

[1]See Alberta, Energy Statutes and Regulations, 82-09-01, pp. 302-304.

[2]Ibid.

[3]Ibid.

[4]See ENR I.L. 79-10.

[5]This is documented in ENR I.L. 78-26.

[6]Copies of this letter are available from the author upon request.

[7]See ENR I.L. 74-4.

SECTION 3

THE TERMS A, B, (A-B)/A, k AND 1 + k(A-B)/A

This section investigates the historical values for the terms A, B, k and 1+k(A-B)/A, as well as limiting values for k and 1+k(A-B)/A. The first subsection focuses on the par price A, the select price, B and the term (A-B)/A. The second subsection deals with the calculation of the terms k and 1+k(A-B)/A.

A. Par Price, A, and Select Price, B, and (A-B)/A

In the calculation of the provincial royalty R, given previously to be R = S(1 + k(A-B)/A), the term (A-B)/A plays a significant role. During the period 74-04-1 to 82-12-31, the select price B--essentially a base price--changed only three times, whereas, the par price A changed numerous times reflecting increases in the price of crude. The par and select prices for the period 74-04-01 to 82-12-31 are listed in Table 3.1 (in Imperial and metric units).[1]

Initially the select price, B, was set at $4.11/bbl, effective 74-04-01 (as documented in ENR I.L. 74-8).[2] Effective 75-01-01 the select price was increased to $4.71/bbl (as documented in ENR I.L. 75-1).[3] The metric equivalent of the $4.71/bbl is $29.64/$m^3$. The latest change in B, effective 82-04-01, was announced in ENR I.L. 82-10.[4] B was increased to $40.90/$m^3$ or equivalently, $6.50/bbl. The initial announcement of this change in the select price, B, was made by the Premier of Alberta on 82-04-13 in "The Alberta Oil and Gas Activity Program."[5] It was indicated in this announcement that the per barrel base or select price would increase from $4.40 to $6.50, for old and new oil (including NORP oil). The move to $6.50/bbl was to "recognize the need to offset higher operating costs in virtually all oil areas of Alberta."[6] Apparently the $4.40/bbl refers to the $4.71/bbl, as there is no documentation of a change from $4.71/bbl to $4.40/bbl. The last posted select price, prior to the ENR I.L. 82-10 (dated 82-04-21) posting,

TABLE 3.1

PAR AND SELECT PRICES FOR NEW AND NORP OIL
74-04-01 to 82-12-31

Effective Date	Source	Par Prices		Select Prices	
		$/bbl	$/m^3	$/bbl	$m^3
74-04-01	I.L. 74-8	6.81	42.85	4.11	25.86
75-01-01	I.L. 75-1			4.71	29.64
75-07-01	I.L. 75-10	8.31	52.29		
76-07-01	I.L. 76-7	9.36	58.90		
77-01-01	I.L. 77-5	10.06	63.31		
77-07-01	I.L. 77-8	11.06	69.60		
78-01-01	I.L. 78-2	12.06	75.89		
78-07-01	I.L. 78-19	13.06	82.18		
79-07-01	I.L. 79-9	14.06	88.48		
80-01-01	I.L. 80-2	15.06	94.77		
80-08-01	I.L. 80-13	17.06	107.36		
81-01-01	I.L. 81-2	18.06	113.65		
81-07-01	I.L. 81-7	19.06	119.94		
81-10-01	I.L. 81-9	21.25	133.72		
82-01-01[a]	I.L. 82-2	23.50	147.88		
82-01-01[b]	I.L. 82-2	44.18	278.00		
82-04-01	I.L. 82-10			6.50	40.90
82-07-01[a]	I.L. 82-16	30.27	190.50		
82-07-01[b]	I.L. 82-16	41.47	260.95		

[a]New oil values.
[b]NORP oil values.

was in ENR I.L. 82-2 (dated 82-01-28) where B was set at $4.71/bbl.[7] Reference to Alberta Energy Statutes and Regulations also indicates the select price was $29.64/m^3 ($4.71/bbl) from 75-01-01 to 82-03-31.[8]

The par price is given in Table 3.1 for new and NORP oil. Values for NORP oil par prices occur only for 1982. A distinction is actually made between new and NORP par prices in that new oil has a par price A, while NORP oil has a base price X. In addition, the new oil constant term k is called y for NORP oil. Currently, other than for the different symbols, the royalty formula is the same for NORP oil and new oil.[9] However, this should allow the Province some flexibility in introducing additional differentiation between these two classes of oil at a later date. There does not appear to be any documentation as to how or why the par price, select price or NORP adjusted base price are determined. This information would prove useful for industry in their planning processes. However, it is fairly obvious that the term (A-B)/A tends to one as A tends to infinity, if B is finite, constant and less than A. Therefore, from a planning perspective, the worst case scenario is to assume (A-B)/A to be one. For the current value of B, the term (A-B)/A will be between .8 and .9 for A between $204.50 m^3 ($32.50/bbl) and $409.04 m^3 ($65.00/bbl) respectively.

Figure 3.1 depicts the values of the term (A-B)/A, for four values of B and a range of values for A. A is allowed to vary from $0.00 to $500.00 while B is set at $15.00, $29.64, $40.90 and $50.00, (all prices are in terms of $/m^3). The $15.00 and $50.00 are arbitrary upper and lower values, included for comparison purposes. Increasing B decreases the ratio of (A-B)/A for given values of A, but such decreases become smaller as A becomes larger. The latest change in B, from $29.64/m^3 to $40.90/m^3, has resulted in a 7.0 percent decrease in the term (A-B)/A for new oil and a 4.9 percent decrease for NORP oil, given the current prices for these oil classes (i.e. new oil par price (A) = $190.50/m^3 and for NORP oil base price (X) = $260.95/m^3). Obviously the significance of the impact of the change in B is reduced as A becomes relatively large.

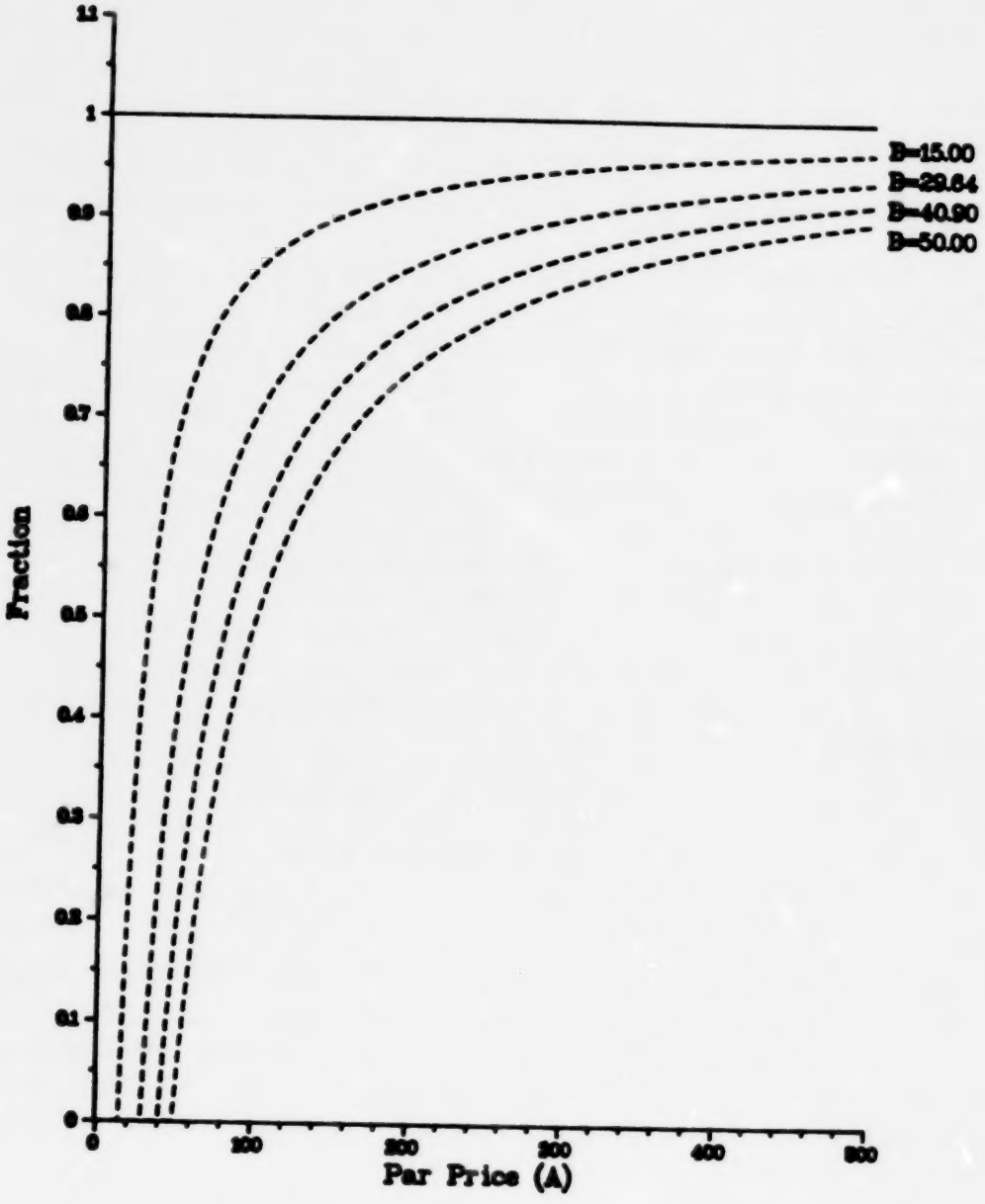

Figure 3.1: (A–B)/A

At the time the change in B was introduced, the impact was somewhat larger for new oil at the relevant par price of $\$147.88/m^3$. The effect was to decrease the ratio of (A-B)/A by 9.5 percent from .799567 to .723424. Whereas for NORP oil (X = $\$278.00/m^3$), the ratio of (A-B)/A decreased by 4.5 percent from .893381 to .852878. The reduced impact for NORP oil reflects the higher NORP oil price effective in that time period. Note that the change in B from $\$29.64/m^3$ to $\$40.90/m^3$ is a 38 percent increase.

In terms of obtaining the objective of offsetting higher operating costs, this latest modification in the select price, provides a fairly limited and temporary form of relief. Furthermore, given that it compensates for nominal operating cost increases since 1975, a more effective mechanism could probably be identified for obtaining and continuing to obtain over time, the stated objective.

B. The Calculation of k and 1+k(A-B)/A

The mystique of the royalty formula lies in the calculations[10] of the constant k. For the purpose of discussing the calculation of k, this section is divided into three components:

a. period one: 74-04-01 to 78-06-30

b. period two: 78-07-01 to 81-09-30 and

c. period three: 81-10-01 to 82-12-31.

The division into these time periods reflects the fact that the formula for k is known only for period two. However, it is expected that the formulae for period one and period three are variations of the period two formula. Period one is of historical interest only, so emphasis is placed on the latter two periods.

Table 3.2 lists the published values for k and the term 1+k(A-B)/A for the period 74-04-01 to 82-12-31. For convenience, 1+k(A-B)/A will be referred to as "the multiplier" and will be denoted by the letter M.

TABLE 3.2

PUBLISHED VALUES FOR k AND THE MULTIPLIER

Effective Date	Source	k	$1+k\frac{(A-B)}{A}$
74-04-01	I.L. 74-8	.560	1.222026
75-01-01[a]	I.L. 75-1	.560	1.172687
75-07-01	I.L. 75-10	.614	1.265993
76-07-01	I.L. 76-7	.596	1.295905
77-01-01	I.L. 77-5	.6154	1.327298
77-07-01	I.L. 77-8	.6262	1.359553
78-01-01	I.L. 78-2	.6311	1.384615
78-07-01	I.L. 78-19	.6303	1.403013
79-07-01	I.L. 79-9	.6293	1.418462
80-01-01	I.L. 80-2	.6283	1.431808
80-08-01	I.L. 80-13	.6268	1.453731
81-01-01	I.L. 81-2	.6261	1.462838
81-07-01	I.L. 81-7	.6256	1.470975
81-10-01	I.L. 81-9	.626919	1.487964
82-01-01[b]	I.L. 82-2	.625769	1.500344
82-01-01[c]	I.L. 82-2	.620338	1.554198
82-04-01[b]	I.L. 82-10	.615256	1.445091
82-04-01[c]	I.L. 82-10	.615552	1.524991
82-07-01[b]	I.L. 82-16	.615369	1.483251
82-07-01[c]	I.L. 82-16	.615480	1.519013

[a]This value of k was imputed based on the values of the par price, select price and the published multiplier for this period.

[b]New oil values.

[c]NORP oil values.

The formula for k for period two in Imperial units is:

$$\frac{S}{\bar{P}}\left(1+k\,\frac{(A-B)}{A}\right) = \frac{\frac{S}{\bar{P}}(B-.31) + .35(A-B)}{A-.31}$$

where .31 is the average provincial gathering charge ($/bbl)
A is the par price ($/bbl)
B is the select price ($/bbl)
$\bar{P}$ is the average provincial monthly production per well (bbl)
S is the royalty factor corresponding to $\bar{P}$ (bbl)
A-.31 is the wellhead equivalent of the par price ($/bbl)
B-.31 is the wellhead equivalent of the select price ($/bbl)
A-B is the increment of the par price over the select price ($/bbl)

Application of this formula, utilizing the known values of the constants, results in the generation of the published values of k for period two. Choosing most likely values for the constants and introducing some modifications to the formula allows one to generate the k values for period one and period three. Caution must be exercised in utilizing these values, since they are obviously only one combination of many that will generate the desired k values.

Some general comments respecting the above formula for k are in order before looking at specific k values for the three time periods.

The left-hand side of the above formula can be considered as an average royalty rate and is therefore dimensionless. The right-hand side is also dimensionless and is the portion of the wellhead equivalent of the par price that consists of a weighted combination of the wellhead equivalent of the select price and the incremental par price divided by the wellhead equivalent of the par price. The term k is chosen to equate the two fractions depending on the values of A, B, $\bar{P}$ and S.

$\bar{P}$ has been set at 3600 bbls/well/month from at least 78-07-01 and will remain at this level until at least

87-01-01.[11] By applying the formula for S in Section 2, S has a value of 780 for $\bar{P}$ = 3600. Let c = $S/\bar{P}$ which is equal to .21$\bar{6}$ for S = 780 and $\bar{P}$ = 3600.

Rearranging the above formula and solving for k gives:

$$k = \frac{.35A - cA}{cA - .31c}$$

Substituting the value of c into the formula gives:

$$k = \frac{.13\bar{4}A}{.21\bar{6}A - .06716}$$

Obviously this formula is independent of B, the select price, and modifying B will have no effect on k. The value of k tends to .615385 as A, the par price, tends to infinity.

If the formula for k given at the beginning of the section is expressed in terms of A and B without the $.31/bbl gathering charge, that is:

$$\frac{S}{\bar{P}}\left(1+k\,\frac{(A-B)}{A}\right) = \frac{\frac{S}{\bar{P}}(B) + .35(A-B)}{A}$$

then $$k = \frac{.35}{c} - 1$$

which for c = .21$\bar{6}$ results in a constant value of k = .615385.

This result is clearly independent of both A (the par price) and B (the select price). Therefore, k is then determined on the basis of the choice of $\bar{P}$. The choice of $\bar{P}$ determines the ratio $S/\bar{P}$ which is constrained to the interval $0 \leq S/\bar{P} < 0.25$. There is an inverse relationship between k and $\bar{P}$ which is shown for select values in Table 3.3. It was assumed that the $.31/bbl gathering charge was not included in the calculation of k.

TABLE 3.3

SELECT VALUES FOR $S/\bar{P}$ AND k

$\bar{P}$		$S/\bar{P}$	k
bbl/mo.	m^3/mo.		
0	0	0	undefined
400	63.56	.05	6
700	111.24	.0875	3
800	127.13	.10	2.5
1200	190.7	.15	1.3
2400	381.4	.20	.75
3600	572.1	.216	.615385
4800	762.8	.225	.5
∞	∞	.25	.4

By choosing larger values for $\bar{P}$, the ratio $S/\bar{P}$ increases, which results in the value of k decreasing. The effect of decreasing k is to reduce the multiplier and therefore the average royalty. Given the royalty formula:

$$R = S\ (1+k(A-B)/A)$$

then $\frac{R}{\bar{P}} = \frac{S}{\bar{P}}\ (1+k(A-B)/A)$ is the average royalty rate,

where P is the producers production per well per month in m^3.

The average monthly royalty rate the producer pays per well for production (P) has upper limits for particular values of k (reflecting the provincially determined value for $\bar{P}$). Assuming that (A-B)/A has approached its maximum value of one, those upper limits would be defined as:

$$\frac{R}{\bar{P}} = \frac{S}{\bar{P}}\ (1+k)$$

If k has approached its minimum value of .4 (i.e., $S/\bar{P}$ = .25) and the producer is producing at a level such that S/P is .25 then the average royalty rate would be .35. Given the current value of $\bar{P}$ of 3600 bbl (i.e.,

$S/\bar{P}$ = .21$\bar{6}$) then k would have a value of .615385 and the average royalty rate would approach .4038 if S/P = 0.25. However, should $S/P = S/\bar{P} = .21\bar{6}$, reflecting production at the average provincial production level ($P = \bar{P} = 3600$), then the average royalty rate would be 0.35.

There are numerous other observations that can be made regarding the formula for k and M, but the essence of their relationship is clear. The following three figures, Figure 3.2, Figure 3.3 and Figure 3.4, highlight this relationship.

Figure 3.2 presents the relationship between k and the par price. The formula for k included the gathering charge of \$.31/bbl (\$1.95/m^3). The results are presented for four values of $\bar{P}$, the provincially set average monthly production figure. For each case, k approaches its limiting value fairly quickly, irrespective of the arbitrarily set value of $\bar{P}$, which indicates that k may as well be a constant. This is especially true for the current value of $\bar{P}$ at 3600 bbl (572.1 m^3) and the current values of the par price for new and NORP oil.

Figure 3.3 presents the value for the multiplier, for the four values of $\bar{P}$ utilized in Figure 3.2. The k factors are calculated as they were in Figure 3.2 and the result of the interaction with the term (A-B)/A for two values of B is shown. The two B values are \$29.64/m^3 (\$4.71/bbl) and \$40.90/m^3 (\$6.50/bbl). If A = B, then the multiplier equals one. For the four values of $\bar{P}$, the multiplier quickly approaches its limit and the effect of the different values for B is dampened fairly quickly. This is particularly apparent for the current value of $\bar{P}$ = 3600 bbl (572.1 m^3). A quick comparison between Figure 3.2 and Figure 3.3 indicates that the term (A-B)/A is the dominant term in the multiplier.

Figure 3.4 demonstrates the relationship between the average royalty for various levels of production for five possible values of $\bar{P}$. These values in m^3 (bbl) are: 190.7 (1200), 381.4 (2400), 572.1 (3600), 1144.2 (7200) and

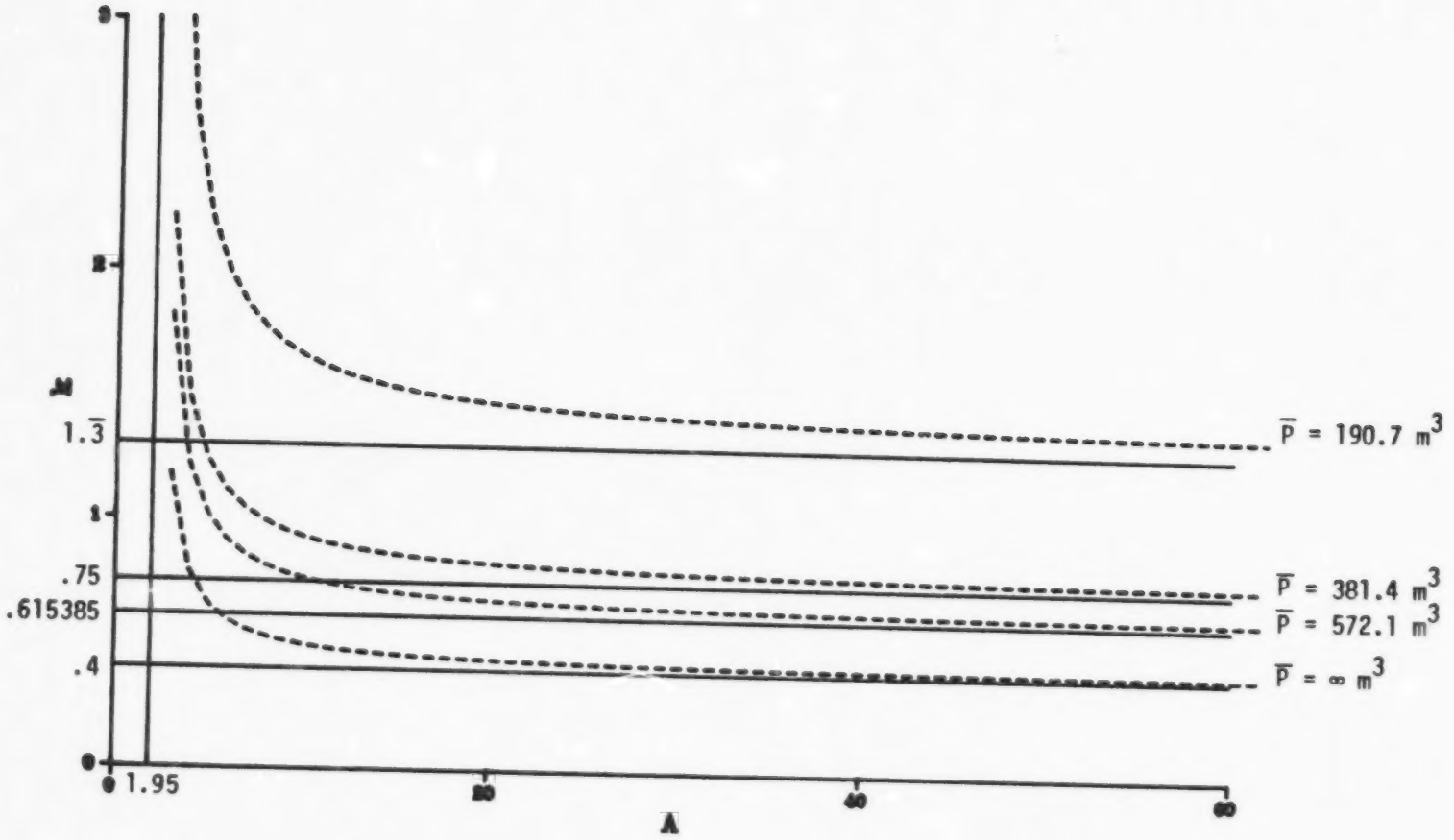

Figure 3.2: k versus Par Price(A) in $/m^3

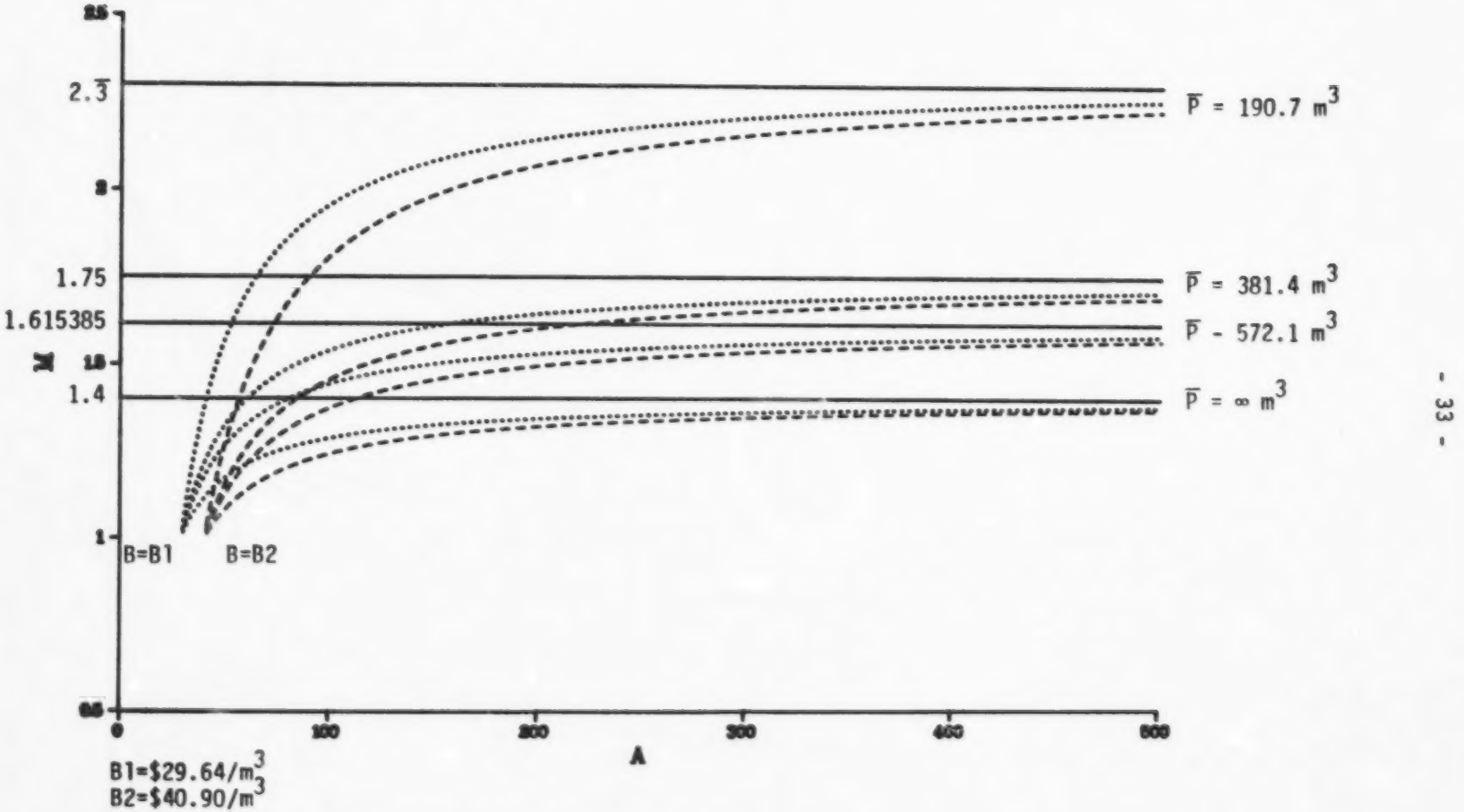

Figure 3.3: The Multiplier 1+k(A−B)/A

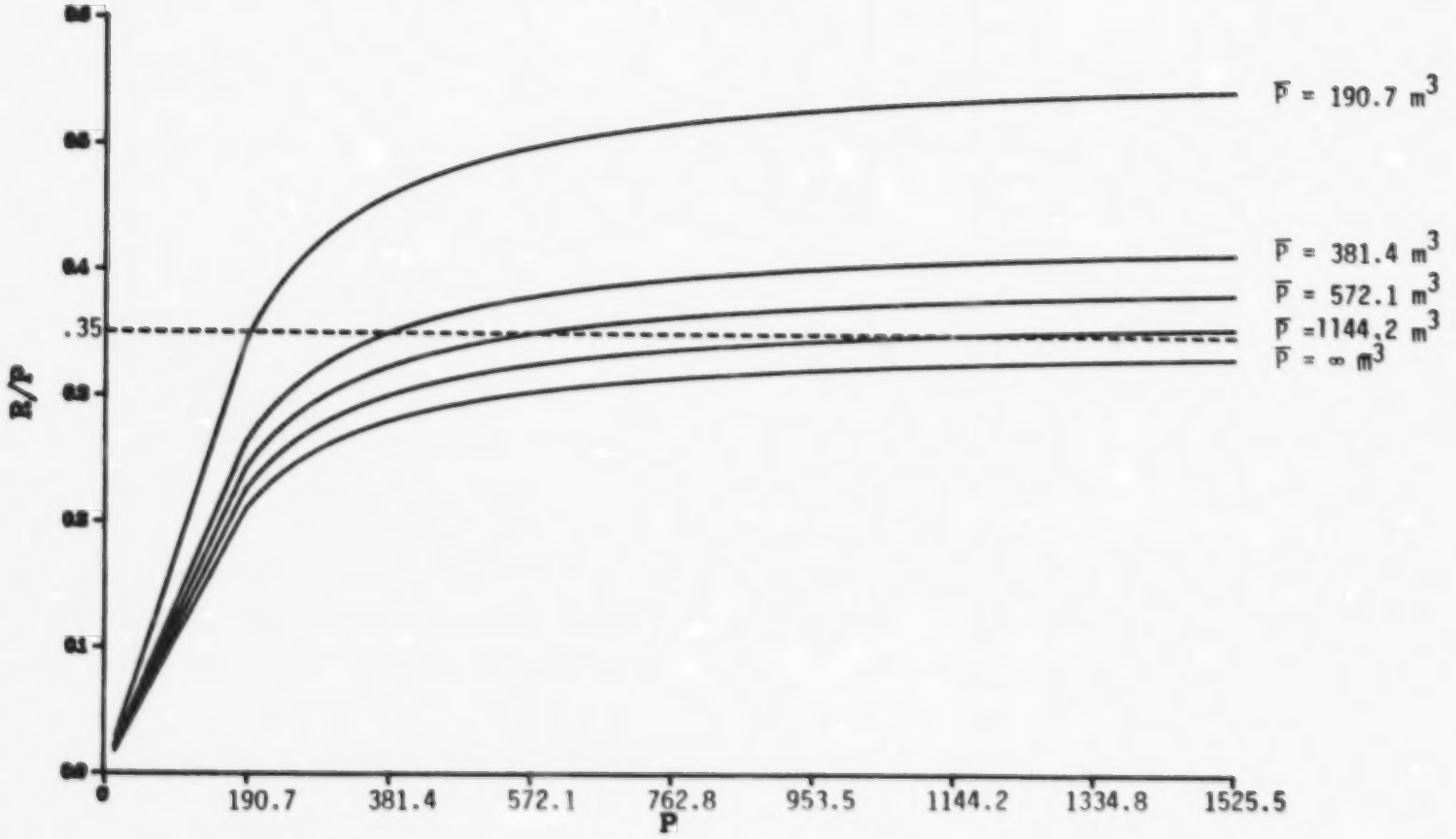

Figure 3.4: Average Royalty versus Production for Five $\bar{P}$'s (m3)

infinity as a limiting case. It is also assumed that the term (A-B)/A has a value of one and that the respective k values are the limiting values from Figure 3.2. These $\bar{P}$ and k values are presented in Table 3.4.

TABLE 3.4

SELECT VALUES FOR $\bar{P}$ AND k

$\bar{P}$ (m^3)	k
190.7	$1.\bar{3}$
381.4	.75
572.1	.615385
1144.2	.5
∞	.4

For each of the cases, when actual production (P) is equal to $\bar{P}$, the average royalty is .35. Obviously, average royalties increase at an increasing rate for decreasing values of $\bar{P}$. The limiting average royalty rate for each $\bar{P}$ is given in Table 3.5.

TABLE 3.5

$\bar{P}$ AND LIMITING $R/\bar{P}$ VALUES

$\bar{P}$ (m^3)	limiting $R/\bar{P}$
190.7	$.58\bar{3}$
381.4	.4375
572.1	.4038
1144.2	.375
∞	.35

Somewhat peculiar results develop if a $\bar{P}$ of less than 190.7 m^3 is selected. From industry's perspective, high $\bar{P}$ figures are most desirable.

The preceding gives some insight into a related point respecting old oil that was identified in the paper, "The Alberta Oil and Gas Activity Program," where it was stated that:

> The emphasis on old oil will correct certain deficiencies in the royalty formula which have

> led to unacceptably high royalty rates on high productivity wells. In fact, if the royalty formula had not been changed, a situation would have arisen whereby a price increase would actually reduce the producers' revenues from a high productivity well.[12]

This passage refers to the reduction from 50 to 45 percent of the marginal royalty rate on the portion of the price in excess of the select price. These values for the old oil royalty rate correspond to the 35 percent for new oil. The situation where "a price increase would actually reduce the producers' revenues from a high productivity well" could only occur if the par price increased to a point such that the term R/P becomes greater than .5; that is, if R/P = S/P x M > .5 for a change in A, hence a change in M. Under the old rules R/P could approach a maximum of approximately .5769. This would occur for very high production levels (P) and very high par prices (A). It should be noted that this situation can still arise under current rules, for R/P can reach a maximum of approximately .5192. It would be interesting to know what fraction of Alberta production was subject to this phenomena and what portion of Alberta production may similarly be affected by the current rules some time in the future. Note that this is not a problem for new or NORP oil, as the maximum for R/P is approximately .4038.

Period One Values

The period one values for k and the multiplier are discussed in this section. Table 3.6 lists the required k values to generate the published M values for the stated values of A and B. That is, k is solved for in the following formula, $M = 1 + k(A-B)A$, by substituting the published values for M, A and B, into the formula, then rearranging. The resultant k values are called calculated k values and are compared to the published values.

TABLE 3.6

PERIOD ONE k and M VALUES

Case	Source	M	B ($/bbl)	A ($/bbl)	Published k	Calculated k
1	I.L. 74-8	1.222026	4.11	6.81	.560	.560000
2	I.L. 75-1	1.172687	4.71	6.81	.560	.560000
3	I.L. 75-10	1.265993	4.71	8.31	.614	.614000
4	I.L. 76-7	1.295905	4.71	9.36	.596	.595628
5	I.L. 77-5	1.327298	4.71	10.06	.6154	.615443
6	I.L. 77-8	1.359553	4.71	11.06	.6262	.626245
7	I.L. 78-2	1.384615	4.71	12.06	.6311	.631083

For the first three cases the published k values are exact to six decimal digits. The last three cases are correct with rounding to four decimal digits, but the calculations for M were probably performed with the six decimal digit figures. For the fourth case (.596) the published number would be correct with rounding of the calculated value to only three decimal digits. It is interesting to note that the change in the select price B from $4.11/bbl to $4.71/bbl had no effect on the value for k, from case one to case two. This is not surprising, given that the period two formula for k is independent of B. The only impact is a significant decrease in the multiplier resulting from a change in the term (A-B)/A.

Assuming the period two formula for k is basically the same formula utilized in period one, then by modifying $\bar{P}$ and the gathering charge (GCH) of $.31/bbl, it generates k values very close to the published and calculated k values. The required values for $\bar{P}$ and GCH are given below in Table 3.7, along with the resultant generated k-values.

TABLE 3.7

PROBABLE VALUES OF THE CONSTANTS FOR THE PERIOD ONE k FORMULA

Case	Source	Published k	Calculated k	$\bar{P}$ (bbl)	GCH ($/bbl)	Generated k
1	I.L. 74-8	.560	.560000	4680	0	.560000
2	I.L. 75-1	.560	.560000	4680	0	.560000
3	I.L. 75-10	.614	.614000	4000	.31	.613807
4	I.L. 76-7	.596	.595628	4300	.31	.595644
5	I.L. 77-5	.6154	.615443	3900	.31	.615457
6	I.L. 77-8	.6262	.626245	3700	.31	.626249
7	I.L. 78-2	.6311	.631083	3600	.30	.631083

Although little faith can be placed in these assumed values for $\bar{P}$ and GCH (because a variety of combinations of terms can be chosen which will generate k values similar to the ones presented here), there is some historical consistency in the values for $\bar{P}$ and GCH. The first two cases have a zero GCH, but then a positive value of .31 is introduced and maintained until the last case where possibly a rounding error results in the .30 figure. For the $\bar{P}$ values, with the exception of the third case (the first that has a positive GCH number associated with it), the $\bar{P}$ values decrease to the period two value of 3600.

Period Two Values

As for the period one values, the required value of k is calculated which could be used to generate the published multiplier value for the stated values of A, B and M . These are presented in Table 3.8.

Note that commencing with case 2, the calculations were to be performed utilizing metric units and the values of A and B were published in metric terms. The use of the comparison of terms to six decimal digit precision reflects the methodology for royalty calculations that ENR established in their letter of 79-01-25 to "Operators Producing Conventional

TABLE 3.8

PERIOD TWO k AND M VALUES

Case	Source	M	A		B		Published k	Calculated k
			$/bbl	$/m^3	$/bbl	$/m^3		
1	I.L. 78-19	1.403013	4.71	29.64	13.06	82.18	.6303	.630341
2	I.L. 79-9	1.418462	4.71	29.64	14.06	88.48	.6293	.629258
3	I.L. 80-2	1.431808	4.71	29.64	15.06	94.77	.6283	.628319
4	I.L. 80-13	1.453731	4.71	29.64	17.06	107.36	.6268	.626770
5	I.L. 81-2	1.462838	4.71	29.64	18.06	113.65	.6261	.626134
6	I.L. 81-7	1.470975	4.71	29.64	19.06	119.94	.6256	.625568

Crude Oil" on the "Conversion of the Petroleum Royalty Formula to S.I. (Metric) Units for Royalty Calculation and Verification Purposes". With rounding to four decimal digits the published k values are "correct" but the calculated values were probably used.

Table 3.9, lists the published and the calculated k values, and the generated k values using the period two formula for k, performing the calculation in \$/bbl and $\$/m^3$.

TABLE 3.9

PERIOD TWO k VALUES

Case	Source	Published k	Calculated k	Generated k	
				\$/bbl	$\$/m^3$
1	I.L. 78-19	.6303	.630341	.630347	.630349
2	I.L. 79-9	.6293	.629258	.629259	.629253
3	I.L. 80-2	.6283	.628319	.628318	.628313
4	I.L. 80-13	.6268	.626770	.626774	.626769
5	I.L. 81-2	.6261	.626134	.626132	.626128
6	I.L. 81-7	.6256	.625568	.625559	.625555

As expected, the generated k values using \$/bbl and $\$/m^3$ terms are very similar, with differences occurring only in the fifth and sixth decimal positions. It is surmised that the provincial government's calculations were done in \$/bbl. The generated values are very close (i.e., to the fifth decimal position) to the calculated values. Differences may result due to rounding and to the order of the operations. The last case indicates there is some possibility of error in the published M figure, given the difference between the generated and calculated values. This too however, could be explained by rounding error. The salient characteristic of period two is that the k factors are decreasing as the par price, A, is increasing. This is as anticipated, based on the formula for k.

Period Three Values

The period three values of A, B, k and M are reproduced in Table 3.10 for reference.

TABLE 3.10

PERIOD THREE k AND M VALUES

Case	Source	Commencement Date	Par Price ($/m^3)	Select Price ($/m^3)	Published k	Published M
1	I.L. 81-9	81-10-01	133.72	29.64	.626919	1.487964
2	I.L. 82-2[a]	82-01-01	147.88	29.64	.625769	1.500344
3	I.L. 82-2[b]	82-01-01	278.00	29.64	.620338	1.554198
4	I.L. 82-10[a]	82-04-01	147.88	40.90	.615256	1.445091
5	I.L. 82-10[b]	82-04-01	278.00	40.90	.615552	1.524991
6	I.L. 82-16[a]	82-07-01	190.50	40.90	.615369	1.483251
7	I.L. 82-16[b]	82-07-01	260.95	40.90	.615480	1.519013

[a]New oil values.
[b]NORP oil values.

The period three values for k have apparently been generated from a modified version of the period two formula. This is evident in that the first k value in period three (.626919) is larger than the last k value for period two (.6256; see Table 3.2). Note that the k values are now published using six decimal digit accuracy and that three of the values reflect k values for NORP oil.

For the published values of M, A and B the published k factors are correct to six decimal digits for the seven cases (including the three NORP cases). The case one k value occurring on 81-10-01, had to be calculated in $/bbl ($21.25/bbl instead of $133.72/$m^3$) to obtain the published k factor. Utilizing the metric price resulted in a somewhat higher k factor. However, none of the k values can be generated by the period two formula for k.

Allegedly, the gathering charge of $.31/bbl was dropped from the k-factor formula for period three. This

would help explain the statement in "The Alberta Oil and Gas Activity Program" (p. 4) that the "base or select price will be increased from $4.40 per barrel to $6.50 per barrel" for both new and old oil (and presumably for NORP oil as indicated by subsequent ENR Information Letters), since the $4.40/bbl is the $4.71/bbl minus the $.31/bbl gathering charge. But, as shown earlier, the formula for k is independent of the select price, B; therefore, this can not explain the period three k values. Furthermore, if the gathering charge is dropped, then the formula for k is independent of the par price, A, and k is a constant. Therefore, some other modifications must have been made to the formula for k. It should also be noted, that for the term (A-B)/A in the multiplier calculation, B had the value of $4.71/bbl ($29.64/m^3) for all calculations until it became $6.50/bbl ($40.90/m^3).

Although the k-factors generally appear to have the properties that are expected--as do the more important multiplier terms--there do appear to be some peculiarities associated with individual k-values which must, to some extent, affect the multipliers. Therefore, these values are examined in greater detail and some probable formulations for their determination are postulated.

Some additional observations respecting the seven k values relative to the period two formula are given below:

1. The k values for case 4 and case 6, both new oil cases are below the limiting value of .615385 for k.

2. The inverse relationship between k and par price holds for the first three cases whereas the opposite is true for the last four cases (that is k becomes larger as the par price increases).

3. The par price for case 2 and case 4 is equal but the k values for case 2 is larger than case 4. The select price however, has changed, but the value of k should be independent of the select price.

4. The par price for case 3 and case 5 is equal but the k value for case 3 is larger than case 5.

Modifying the period two formula for k,

$$k = \frac{(c(B-.31) + .35(A-B) - 1) \times A}{c(A-.31)} = \frac{(.35-c)A}{A-B} \quad c(A-.31)$$

to:

$$k = \frac{(c(B-.31) + .35(A-(B-.31)) - 1) \times A}{cA} \quad A-B$$

$$= \frac{(A-(B-.31)) \times (.35-c)}{c(A-B)}$$

generates a reasonably close value for the case one k (.626918) to the published value (.626919); however, the calculation must be performed in Imperial units.

The k values for case 2 and case 3 can be approximated by expressing the above formula in metric units and substituting a $\$2/m^3$ gathering charge for the $\$1.95/m^3$ ($.31/bbl) gathering charge.

such that:

$$k = \frac{(A-(B-2)) \times (.35-c)}{c(A-B)}$$

The resultant k values for case 2 and case 3 respectively are .625794 and .620340 which are fairly close to the corresponding published values of .625769 and .620338. The the last four cases could not be generated by this approach. An alternative formula for the multiplier was found in "Evaluation of Canadian Oil and Gas Properties," by Sproule Associates Ltd., which includes a formula for calculating k. It is noted in this publication that the gathering charge has been dropped from the calculations. This would imply that k should be a constant according to the formula given earlier in this section, but using the approximation in "Evaluation of Canadian Oil and Gas Properties," this would not be the case. The formula for M in Imperial units is given to be:

$$M = 1.615385 - \frac{4}{A},$$

which in metric units would be:

$$M = 1.615385 - \frac{25.2}{A},$$

where A is the par price. The formula for k is given to be:

$$k = (M-1)\frac{A}{A-B}$$

where B = 6.50 and A is the par price.

Using these formulas gives the values listed in Table 3.11 for M and k, for cases four through seven.

TABLE 3.11

SELECT PERIOD THREE VALUES FOR k AND M

		Published		Generated	
Case	Source	M	k	M	k
4	I.L. 82-10	1.445091	.615256	1.445169	.615364
5	I.L. 82-10	1.524991	.615552	1.524840	.615376
6	I.L. 82-16	1.483251	.615369	1.483251	.615370
7	I.L. 82-16	1.519013	.615480	1.518924	.615375

For case 6 the generated M are identical and k is correct to 5 decimal digits. It is interesting to note that for a par price less than the case 6 value of \$190.50/m^3, M and k are overstated while for a par price greater than \$190.50/m^3 M and k are understated. It should also be noted that the generated k values are all less than the limiting value of .615385 and that as the par price increases so do these k values.

These apparent anomalies in the k values, hence presumably in the corresponding values of the multiplier, are small and are of little concern with respect to either the collection or payment of royalties. However, it would be

worthwhile to have the methodology utilized to determine the last four k values clarified.

It is noted that the k value effective 83-01-01, (source I.L. 83-2, dated 83-01-20) for new oil is .615385, the period two limiting value; while for NORP oil, the k value is .615523 and the corresponding par prices for new and NORP oil are $\$195.50/m^3$ and $\$271.20/m^3$, respectively. The NORP oil k value is still higher than the new oil value and, as the NORP par price increases, the corresponding k values also increase, which is contrary to our expectations. The multipliers are 1.486642 and 1.522695 for new and NORP oil respectively. These k values are somewhat surprising given a reference to a paper by ENR, "Mathematical Proof of Constant k-Factor," in the PSI Energy Software newsletter, Progress (Issue C47),[14] January 1983.

To conclude, it is observed that the royalty formula could be simplied to:

$$R = 1.6S$$

where the 1.6 could be set as required. This would be equivalent to the Provincial Government claiming 40 percent of conventional new oil production in the form of royalties, which is the amount that is now collected for high productivity wells. This would also eliminate any confusion regarding the intent or interpretation of the intent, of the provincial government with respect to royalty collection; for the royalty formula would now be a function only of production.

Footnotes

[1]The sources for these numbers are listed in the table as the particular ENR Information Letter in which the values were announced. Reference could also be made to the original Alberta Regulations which brought these values into force; as could Alberta Energy Statutes and Regulations, pp. 305-307, which also lists a number of these values.

[2]See ENR I.L. 74-8.

[3]See ENR I.L. 75-1.

[4]See ENR I.L. 82-10.

[5]See The Alberta Oil and Gas Activity Program, p. 4.

[6]Ibid., p. 5.

[7]See ENR I.L. 82-2.

[8]See Alberta, Energy Statutes and Regulations, p. 305.

[9]Given the similarity of the formula (A-B)/A and (X-B)/X, at this time, A will be interchanged with X throughout the paper, as will k for y.

[10]All calculations are done utilizing rounding as opposed to truncation where applicable.

[11]See the Alberta/Ottawa energy price agreement, pp. 12-14, for an indication that $\bar{P}$ will be constant. The actual value was stated on 82-04-13 in "The Alberta Oil and Gas Activity Program", p. 4.

[12]See "The Alberta Oil and Gas Activity Program," p. 4.

[13]See Sproule Associates Ltd., "Evaluation of Canadian Oil and Gas Properties," pp. VI-2 to VI-8.

[14]See PSI Energy Software, Progress, Issue No. C47, Jan. 1983, which references this ENR paper, "Mathematical Proof of Constant k-Factor." It should be noted that Section Three of this paper was sent to ENR for comments in 82-06-11, respecting the formula for k and the published values of k for the three periods considered here. Period three obviously covered a shorter time period.

SECTION 4

NOMINAL VERSUS REAL IN ROYALTY CALCULATIONS

There is some debate as to the amount of bias associated with calculating royalty payments over time in real terms as opposed to nominal terms and then expressing the results in present value terms for some discount rate.[1] This section provides a formula for calculating the bias and an example of a special case of the problem. There is obviously some non-zero bias in the calculation since the royalty formula is a function of price and price invariably changes over time.

The amount of bias will be a function of a number of parameters. The first group are the standard parameters that affect present value calculations which are the magnitude and timing of the relevant cash flows and the length of the time period the analysis encompasses.

In addition to these factors, the bias is affected by the values of the initial conditions of the constants A, B and k, hence M and the rate and direction of changes in these variables over the relevant period. The closer the multiplier is to its limiting value, the smaller will be the bias, assuming strictly monotonic increases in the multipler. Given the importance of the par price in the calculation of M, the discussion could concentrate on A, as opposed to M.

There are a number of ways of expressing or measuring the bias. The bias can be expressed relative to the constant dollar case or the nominal dollar case, or as as a weighted average of the first two methods. The second case is utilized here.

For the sake of simplicity, three assumptions are made. First, it is assumed that the rate of change in A and the wellhead price of crude are equal. Second, it is assumed that the two prices are equivalent. Third, it is

assumed that production for every month of a year is identical. This last assumption reflects the periodicity of a number of evaluation models.

Given the above, the formula for calculating the bias, as a fraction, associated with performing the royalty calculation in present value terms for constant as opposed to nominal dollars, relative to the nominal dollar amount is:

$$\text{Bias} = \frac{\sum_{t=1}^{n} \frac{\frac{M_C - M_{N,t}}{M_{N,t}} \times RP_{N,t}}{(1 + DR)^{t-.5}}}{\sum_{t=1}^{n} \frac{RP_{N,t}}{(1 + DR)^{t-.5}}}$$

where DR is the discount rate (fraction)
M is the multiplier
C is for constant dollars
N is for nominal dollars
RP is the royalty payment in dollars
t is time in years

Since M is increasing at a decreasing rate, that is, it is approaching an upper limit, the bias associated with performing the royalty calculation, in constant as opposed tc nominal dollars, will become smaller as time passes. An examination of the first differences for the values of the term $M_C - M_{N,t}$ will give some indication of the rate at which the bias will tend to zero. Due to the small numbers involved, rounding errors can play havoc with these calculations, which gives some indication that the information gains and losses are already insignificant regardless of the choice as to nominal versus real values for the royalty calculation given that the results are expressed in present value terms.

If it is assumed that production in each year is constant and the discount rate is zero, then the formula for bias can be reduced to:

$$\text{Bias} = \frac{RP_1}{\sum_{t=1}^{n} RP_{N,t}} \times \sum_{t=1}^{n} \frac{M_C - M_{N,t}}{M_{N,t}}$$

where variables are defined as before but:

$$RP_{C,1} = RP_{N,1} = RP_1$$

An example is given below for this case, i.e., equal annual production over time. Assume a project with a five-year life for which the monthly production is equal for each month of each year. The selling price is equal to the par price. All values are in Imperial units and production is given per month. The multiplier is calculated using a k-value derived with the period two formula. The data for the constant dollar case are:

Year	A ($/bbl)	B ($/bbl)	M	P (bbl/mo.)	S (bbl/mo.)
1	21.25	4.71	1.486077	3600	780
2	21.25	4.71	1.486077	3600	780
3	21.25	4.71	1.486077	3600	780
4	21.25	4.71	1.486077	3600	780
5	21.25	4.71	1.486077	3600	780

where R = M x S such that RP = R x A.

The data for the nominal dollar case, which assumes a 10 percent per annum inflation rate are:

Year	A ($/bbl)	B ($/bbl)	M	P (bbl/mo.)	S (bbl/mo.)
1	21.25	4.71	1.486077	3600	780
2	23.38	4.71	1.497991	3600	780
3	25.71	4.71	1.508793	3600	780
4	28.28	4.71	1.518591	3600	780
5	31.11	4.71	1.527479	3600	780

The discounted totals of the royalty payment streams in real terms in year one dollars for a 0 percent and an 8 percent real discount rate are given below:

Real Discount Rate	Royalty Payment: Constant $ Case	Royalty Payment: Nominal $ Case
0	1477903.58	1499467.13
8	1226466.65	1243057.16

Note that for the nominal dollar case, the 10 percent inflationary component has been accounted for in the present value totals (i.e., the nominal dollar value of the royalty stream was $1833238.92). The bias associated with this particular example is -1.44 percent and -1.33 percent for the real discount rates of 0 and 8 percent respectively. This means that performing the royalty payment calculation in real terms as opposed to nominal terms results in a present value that is 1.44 percent lower than it would have been for a real discount rate of 0 percent. A larger discount rate reduces the bias. Note, the application of the second formula to this example results in a figure of -1.41 percent for the amount of bias, whereas application of the first formula is exact at -1.44 percent for the 0 percent discount rate.

It is easily seen that the preceding formulas can be generalized to account for monthly as opposed to annual production, or for wellhead prices which are not the same as the par prices. In addition, the formulas could be expressed in terms of A as opposed to M. However, it is sufficient to realize that the bias results from differences in the multiplier term, reflecting changes in A, and that these differences become smaller as M approaches its limit. As time passes, the significance of the bias should diminish.

While in the mid-1970s the bias may have been large enough to warrant concern, this is not the case for current values of A, B, k and M.

Footnotes

[1]This question also arises in the context of tax calculations for both stand alone and flow through models. The answers to the questions in these contexts are not as simple. Some preliminary work was done on this topic about one year ago, in the context of a stand alone model for the constant dollar cases--in particular, investigating the effects of cost increases on profit decreases. This and related analysis done more recently will be presented in a forthcoming publication.

SECTION 5

SUMMARY AND CONCLUSIONS

The impetus for this paper resulted from discussions with oil company representatives in 82-02 regarding the profitability of enhanced oil recovery (EOR) in Alberta relative to the Alberta/Canada Energy Pricing Agreement pricing and fiscal regime, the National Energy Program (NEP) pricing and fiscal regime, and the pre-NEP pricing and fiscal regime. It was purported that one reason the Canadian Energy Research Institute's EOR profitablity analysis for these regimes was overly optimistic, was because the royalty calculations were undertaken in constant dollars as opposed to nominal dollars. This paper evolved in response to that criticism.

Although aspects of this paper are available elsewhere or have been published by other groups (although usually as internal documents), there appeared to be a need for a compendium of the historical data relevant to the new Alberta oil royalty formula for the period 74-04-01 to 82-12-31 and for a simple explanation of these values. This information has been provided, as have the interactions between the various variables. In addition apparent inconsistencies in components of the royalty formula values have been identified.

Limiting values for some of the terms in the royalty formula under various assumption sets for the values of the constant terms have also been given. Generally it can be concluded that these limiting values are obtained quickly enough that it would be advantageous to modify the royalty formula, such that it explicitly included these limiting values.

The observed inconsistencies in the values for the constant terms in the royalty formula, particularly for the more recent time period, result in discrepancies in the royalty calculations which are not significant enough to be

of major concern to either resource producers or to provincial royalty collectors.

The main criticism of the new oil royalty formula is the lack of publicly available documentation with respect to the formula and the value and determination of the constant terms. There would be some benefit from having all of the information relating to the constant term k, and the multiplier, M, made public and published in the volume Alberta, Energy Statutes and Regulations, as are the par and select prices. This would avoid confusion inherent in such events as the 82-04-13 announcement of a change in the select price from $4.40/bbl to $6.50/bbl and the corresponding modifications to the $.31/bbl gathering charge and its respective inclusion or exclusion in various calculations, given that the select price was never $4.40/bbl. This would also provide an opportunity to clarify the peculiar relationship that was observed for the k values for NORP and new oil for the two periods 82-04-01 to 82-07-01 and 82-07-01 to 82-12-31.

The question of bias, depending on the choice of nominal or constant dollars for the royalty calculation--expressed in present value terms--has been shown to be insignificant for large values of A. The example used in this paper utilized values for A which are considerably less than current ones, which indicates that the bias would be even smaller for similar calculations utilizing current prices.

This paper does not address a number of interesting issues which could be pursued using this material as a point of departure. One would be an analysis of the current and future composition of Alberta oil production by oil class - old/new/NORP - by broad quality categories and the associated impacts on provincial royalty payment flows. The split between old and new oil is not publicly available for the pre-1982 period, but Energy, Mines and Resources Canada has been publishing this information monthly for total oil production by province during 1982. Another interesting analysis would be the identification of the quantity of oil by class, disaggregated by broad quality groups, that was affected by each change in oil class definition since 81-09-01. This would include consideration of the forecast

values for oil class composition, associated with each definition, and the corresponding distribution of revenue between producers and the two levels of government under various pricing assumptions. Some of the information for this last component has probably already been compiled by both the federal and provincial governments, given its importance as input data in the recent rounds of policy formulation, respecting pricing, taxation and revenue sharing.

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